BNL Science Featured at March 2001 APS Meeting

Karen McNulty Walsh and Diane Greenberg

More than 30 BNL scientists presented their research at the March 2001 American Physical Society (APS) meeting held this week, March 12-16, at the Washington State Convention Center in Seattle, Washington. These four stories feature a sampling of the promising and varied research reported at the meeting.

Revealing the secret of high-performance transducers

Beatriz Noheda, Physics Department, reported on new advances in the study of piezoelectric materials—materials that can be deformed by the application of an electric field, or that produce an electric current when physically deformed.

One of the most important piezoelectric materials is a ceramic known as PZT. It is used as a transducer for transforming the vibrations of sound waves, for example, into electrical current and vice versa in devices such as telephones, sonar systems, and ultrasound machines.

Noheda described the discovery of a previously unknown phase, or crystalline shape, for certain compositions of PZT, which explains their very high piezoelectric response.

“With this new ‘monoclinic’ phase, you no longer have to apply the electric field in the exact direction of the deformation. This material has a lot more freedom to deform,” Noheda says.

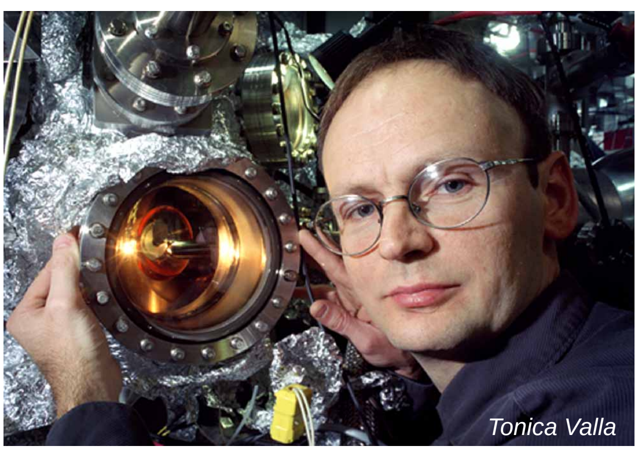
Scientists may now look for this monoclinic phase in other materials and use them as well as PZT to make the next generation of solid-state transducers, which could result in much more sensitive devices. This work was done at the National Synchrotron Light Source.

Exploring electronic states in high-temperature superconductors

Beatriz Noheda

Tonica Valla, Physics Department, presented his group's latest efforts to understand the underlying mechanism for superconductivity in copper-based materials - cuprates - that act as high-temperature superconductors. Like traditional superconductors, these materials carry electrical current with no resistance while in their superconducting state. But Valla's studies at the NSLS reveal that they do not use the same mechanism.

In both traditional and high-temperature superconductors, pairs of electrons carry the electric current,



Tonica Valla

but the "glue" that holds the pairs together may be different.

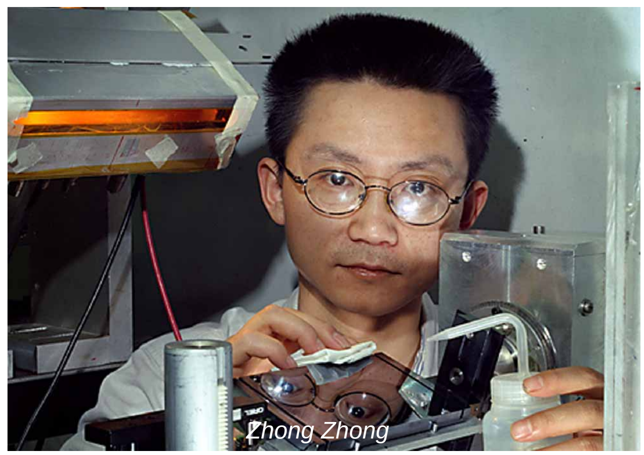
Valla's experiments give direct information about electronic states in these materials and can uncover the interaction that causes pairing of electrons.

The new materials become superconducting at warmer temperatures than do conventional superconductors, which must be kept super cold by surrounding them with expensive liquid helium. Cuprates, however, are superconducting at temperatures "warm" enough to be chilled by less-expensive liquid nitrogen.

"If we understand how these high-temperature superconductors work, then we might be able to make them more efficient so that they can take the place of the more expensive kind in magnets for accelerators, electronic circuits, or even more exotic applications as superconducting railroads and motors," Valla says.

Using new x-ray technique to improve breast imaging

Zhong Zhong, National Synchrotron Light Source (NSLS) Department, and North Carolina State University researchers Miklos Z. Kiss and Dale E. Sayers are investigating a new technique called diffraction-en-



Zhong Zhong

hanced imaging (DEI) to detect and study calcifications of breast tissue.

As Kiss reported at the APS meeting, using DEI, the collaboration looked at a sample of breast tissue with at least ten calcifications and made computer models of the new imaging process to study its contrast mechanisms.

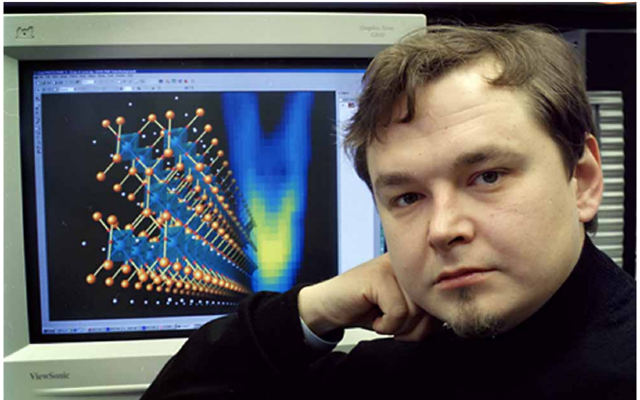
This new method, compared to x-rays used in mammography, significantly improves pictures of breast tissue. Calcifications are associated with breast cancer, and their early detection is crucial for diagnosis and treatment.

DEI was developed and tested at the NSLS by researchers from BNL, the Illinois Institute of Technology, North Carolina State University, and the University of North Carolina. DEI reduces the x-ray scattering that makes for blurry images and lack of contrast in mammograms. The new patented method may one day replace mammograms.

Probing the properties of mixed magnets

Andrey Zheludev, Physics Department, reviewed recent neutron scattering studies of “mixed” quantum/classical magnets.

Conventional magnets are characterized by long-range magnetic order—where the magnetic fields of all the individual atoms are oriented in the same or alternating directions. In contrast, certain one-dimensional magnets become disordered when quantum effects cause oscillations in the magnetic fields of individual atoms.



Audrey Zheludev

“The properties of such systems totally defy the classical picture of magnetism,” Zheludev says.

An outstanding problem in condensed-matter physics is in understanding how classical and quantum magnets interact when combined in a single material.

Zheludev described the discovery and study of the first known experimental example of such “mixed” magnets, which are found in complex rare-earth nickel oxides.

The most important finding is that dynamic properties of these compounds have a unique dual nature, with features of both quantum and classical magnetism.

This study deals with the most basic and fundamental aspects of material magnetism. While unlikely to result in practical applications in the short term, it contributes to the general understanding of how all magnets work.

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